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Purnamawati[*1], R T Mangesa[1], Ruslan[1], Idhar[1]

[1] Engineering Faculty, Universitas Negeri Makassar, Indonesia

*E-mail: purnamawati@unm.ac.id,

Abstract. Learning is a process that involves educators, students, teaching materials, learning resources, learning media, and methods. The conventional method, whose main source of knowledge is only from educators, is considered to be less effective if it is the only source of knowledge transfer to students. The boring learning process, the media used in Digital Electronics courses is a simulator, the features presented in the simulator are less interesting. So it was appointed a research study on the development of the IoT Remote Lab learning tool with Blended Learning Digital Electronics Subjects in accordance with the Industrial Revolution era 4.0. This study aims to determine the stages and feasibility of developing the IoT Remote Lab learning tool with a valid, practical, and effective Blended Learning method in the Department of Electronics Education Faculty of Engineering Universitas Negeri Makassar (FT-UNM). The research method used by Research and Development (R&D) with the 4D development model (1), (2) planning, (3) development, and (4) distribution. The results of this study indicate that the Remote Lab IoT learning tool with the Blended Learning method has a very valid category to use. Got a response from students who said it was very practical in its use and the results of student test scores after implementation had increased. It was concluded that the data stated that the Remote Lab IoT learning device with the Blended Learning method that had been developed was declared valid/feasible to use as well as practical and efficient in its use.

Keyword: IoT, Digital Electronics, Blended Learning, R&D.

1. Introduction

Learning is a process of the education system that involves educators, students, teaching materials, learning resources, learning media, and methods. The success of learning can develop the student's potentials so they can get benefit directly and indirectly in their personal development. The responsibility and key success of learning are in the teacher. This means that the lecturers must do their obligation to organize the learning process perfectly so that the necessary components of learning can achieve the goals of it.

Preparing teaching materials before learning is a lecturer's duty that must be completed. If a lecturer doesn't have the ability to develop varied teaching materials, then the lecturer is not in a monotonous

learning situation and tends to be boring for students. This causes the quality of teaching materials not to be produced properly.

Currently, learning that focuses on lecturers is still less effective when it is used as the only resource in transferring knowledge to students. The rapid advancement of technology affects all sectors, including education. The role of lecturers as facilitators should be able to facilitate the students to find their own learning process, especially digital electronics courses in the Department of Electronic Engineering Education, Faculty of Engineering, Universitas Negeri Makassar even in the learning of theory and practice.

One of the systems that help in accessing the laboratory is using applications or computer networks through the remote system. The Remote access system is a network management application to monitor and control computer usage in the laboratory through a certain tool on a client server-based network [1]. The research of [2] uses communication tools connected to Android smartphone devices. An Android smartphone can communicate with the AT Mega 16 microcontroller using Bascom AVR language for the program. It can control other devices to move around, namely servo motors using logic gates. Microcontrollers are also combined with microprocessors to improve the processing data quickly, one of the devices that can be used is Node MCU. This device has excellent capabilities when connected to the internet. Therefore, there must be internet media in learning. With the development of the Internet of Things (IoT), the internet can be utilized for other purposes that strongly support the learning process, such as by theoretical and practical learning activities using the internet [3].

The learning process must be adapted to the era of industrial revolution 4.0 with real-time control known as IoT, then lecturers must prepare the learning media in accordance with the industrial revolution 4.0 in order to improve the competence of graduates. It utilizes the internet as a real-time controlling medium. IoT can be used as a remote learning media specifically designed for controlling the equipment in the lab. In addition, the lecturer expected to facilitate students to study without limited space and time (anywhere and anytime). It is intended that e-learning methods can make the students more active and creative in learning [4].

Based on the results of the interviews of students and lecturers of the Department of Electronic Engineering Education FT-UNM, it produces information from the students that the learning process is boring and the media presented is less interesting. In addition, the information from lecturers is the enthusiasm of students in the learning process is lack. Based on this fact, it is necessary to optimize the learning process by designing an IoT-based learning media.

Thus, a new syllabus, lesson plan (RPS), and media adjustments are needed to attract students. Besides that, to maximize the learning process, a new learning model is required, namely blended learning. The blended learning model is the combination of conventional (face-to-face) learning and e-learning models. It means that blended learning is conventional learning supported by e-learning to make the learning process run optimally. The advantages of these two models can complement the weakness of each other [5].

Based on these problems, it can provide a good solution in designing IoT Lab remote-based learning media with the Blended Learning method. The development of learning media using Node MCU can control and monitor each active gate using the camera through the Internet. This media can support students to do a practicum in a long-range and we expected to achieve an effective learning process.

2. Research Method

This research used a 4D development model, with stages: (1) Define, (2) Design, (3) Develop, and (4) Disseminate. The 4D is the resulting study of several development models namely the Borg and Gall models, ADDIE Instructional Development Models, and ASSURE. After reviewing several models that are suitable for the development of learning devices in the classroom, the 4D consisting of 4 stages with a development flow will be chosen.

3. Result and Discussions

3.1 Device development stages

The Stage of Define follows the steps of doing the initial analysis to obtain some urgent information in the learning of digital electronics courses. This course is compulsory in the Department of Electronic Engineering Education. Furthermore, it is obtained information that students are less enthusiastic, boring, and media using simulator features which less interesting. Based on the problem, improving the learning process is required supporting media to do the analysis tasks and concepts, analyze tasks by creating basic logic gate experiments, then analyse concepts by collecting practicum results in the form of reports. The next stage is an analysis of the goals of learning by adjusting the syllabus, RPS and learning device support media with a blended learning approach.

The design stage is compiling the test assessment of the Digital Electronics course by collecting practical results such as reports or test results. The collection of test reports using 3 ways namely; classroom account, and use Google Form. This selection is being adapted to the conditions. The grating pre-test is suitable for the Course Learning Achievement. The first test is using 3 respondents, this pre-test is only testing the students' knowledge of logic gates.

The IoT remote lab creation stage aims to control the media of practicum learning remotely in real-time. A Remote Lab is the application software of Digital Electronics Trainer, this media can only be used to practice Digital Electronics which only covers every basic gate of digital electronics. The Digital Electronic IoT Remote Lab consists of 4 parts namely User (Student), Remote Lab (Android App), Internet (Media), and Trainer (Practicum Tool).

Communication will be held between the User and the Remote Lab IoT application. Remote Lab IoT connected to Trainer is using internet media. To make it is required multiple applications, such as Software parts using Adobe XD, Android Studio, Arduino IDE, to create hardware parts using Solidwork, Diptrace, and Corel Draw. The firebase is used to store data.

Figure 1. Remote Lab IoT Trainer

Once the design of learning devices and trainers has been well designed, then the next step is to develop media equipped with validated instruments (material expert validation and design validation).

Based on the material expert validation results, Figure 2 illustrates the validation of material feasibility aspects obtaining a percentage of 98.44% in the category of excellent (decent), language eligibility aspect gaining 96.88% percentage in the category is excellent (feasible), and the presentation eligibility aspect gets a percentage of 91.67% in the category of excellent (worthy). The overall calculation result reached 96.66% in the "excellent (decent)" category.

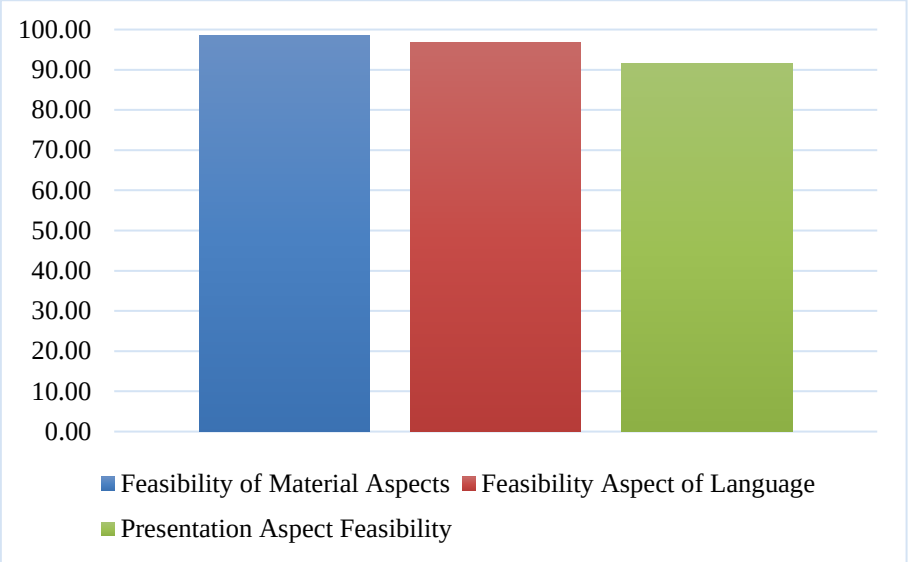

Figure 2. Material expert validation results

Based on the validation results of the design experts who have presented Figure 3. It can be seen that the app and device aspect gained a percentage of 96.88% in the category very well (decent), and the display aspect gained a 100.00% percentage in the category very well (decent). The overall calculation result in the category is "excellent (decent)".

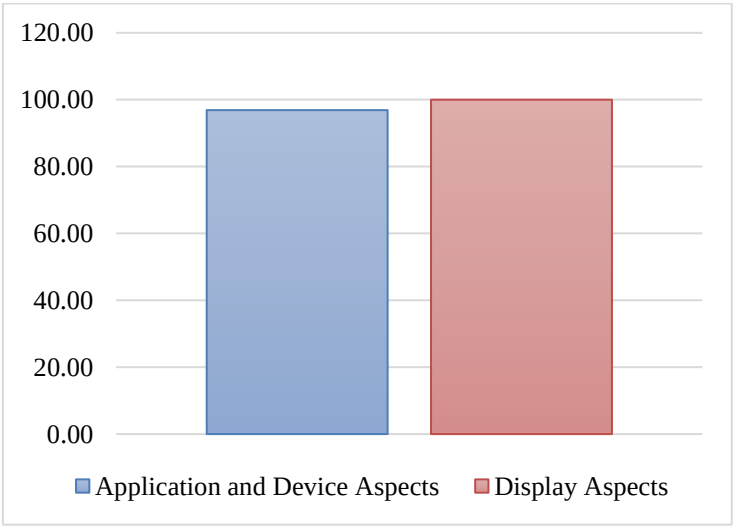

Figure 3. Design validation results

The validation stage of the students' response questionnaire is an instrument that results form the basis of the decision, namely: knowing the practicality of Remote Lab IoT used and corrected the lack of shelling of the device made. Based on the results of the respondents (shown in the attachment), it can be seen that the result of the respondent to practically obtain a percentage of 84.17% in the category is excellent (decent).

3.2 *Deployment*

This stage requires 2 phases of activity that is the Pre– Test which used as the initial data and the Post – Test used as the final data to see the comparison and percentage of product success.

The total percentage of results from Pre Test and Post Test against Remote Lab IoT obtained the results of pre-test from the respondents get a percentage of 88.00 %. Meanwhile, post-test results that can be seen from respondent's results get a percentage of 91.90 %.

3.3 *Discussions*

The results study of [6] concluded that the effectiveness of teaching materials was determined based on the results of post-test mathematics literacy showing the percentage of completed learning of students reached 82.76%. This shows that the teaching materials developed are effectively used to facilitate the achievement of students' mathematical literacy; in addition, the result of [7] concluded that PAI learning evaluation results showed well because the final results obtained by students from the field reality are above the minimum graduation limit of 65%.

The research of [5] aims to, (1) find audio-video expertise package learning in vocational high schools, (2) produce a Blended Learning Audio-Video (BLAVO) model that meets the practical criteria in vocational high schools.

This study is the research and development of educational research (educational research and development). The procedure of BLAVO Model development consists of 2 (two) stages, as pre-development (research) and development, the research and development results are; (1) management of audio-video learning packages in vocational high schools is still conventional so the learning is done only face-to-face in the classroom or the laboratory. The Lecturers have done planning the learning devices, and have evaluated defenses, but still minimal on the learning strategies/methods, use of learning media, and the management of learning resources. (2) Models of Blended Learning Audio-Video (BLAVO) and learning devices in Vocational High School (SMK) have valid criteria that are indicated by expert and practitioner applicants. (3) Models of Blended Learning Audio-Video (BLAVO) and learning devices in vocational high schools (SMK) have practical criteria by the implementation of BLAVO and the ability of teachers to manage the learning. (4) The model of Blended Learning Audio-Video (BLAVO) and learning devices in SMK have the effective criteria shown by the activities of students in learning and positive response from the implementation of learning and achievement of learning competencies of students.

Research [8] found that collaboration between lecturers and students in utilizing blogs provides a good relationship to increased collaboration between them. The use of this Blog makes it easy for lecturers and students to share information and interact whether it is personal or group/general. Collaboration activities also occur not only in the campus environment but also anytime and anywhere. The effectiveness and efficiency of the use of Blog as a CSCL learning media with several indicators obtained very effective and excellent assessment.

The results study of [5] showed that despite the instructional training format in Portugal is dominant face-to-face (65%), e-learning 15%, and the last is blended learning with 20%. The data also revealed that 50% of remote training coordinators believe that B-learning produces better research results than face-to-face training alone when considering the same content and learning objectives. Also, when comparing B-learning and e-learning outcomes with the same content and learning objectives, 78.1% of the coordinators stated that blended learning produces better results than e-learning itself.

[9] shows that: (1) The results of studying Physics using the PBL-BL model are higher than IN-BL; (2) There is an interaction between BL-based learning models and learning motivation to physics learning outcomes; (3) for students who are highly motivated to study, the results of studying Physics with the PBL-BL model are higher than DI-BL. The results of the study [10], showed that: (1) There was a significant improvement in students' learning achievements (t count=16.60>t table=2,002) in the study of lathe machining techniques at SMK 3 Muhammadiyah Yogyakarta after they use the blended learning methods; (2) there is a difference in learning achievement (t count=13.16>t table=2,002)

between class XI TP4 taught using blended learning method with class XI TP2 which does not use blended learning method.

The research is done by the development of the Blended Learning model with IoT which combines the scientifically based classical learning model with e-learning or online learning. The development of science and technology is very rapid, especially the development of the internet. So, the learning process needs the internet to be a learning medium. With the development of the Internet of Things (IoT), the internet can utilize for theoretical and practical learning activities [3], IoT allows users to manage and optimize the electronics and electrical equipment that use the internet. Internet users are increasing with various facilities and services. In general, IoT can be interpreted as connecting various objects around an internet network. To implement it, IoT requires a line of communication that required the needs of the system. One protocol that fits the IoT concept implementation is the Message Queue Telemetry Transport (MQTT) protocol. One of the issues that remains a weakness in IoT budgeting is security and privacy issues. Attacks on IoT security can include attacks on RFID labels, communication networks, and data privacy. The results study of [11] said that The Concept of the Internet Of Things In Web-Based Learning using the method of literature, then designing the concept of web-based learning collaborated with IoT devices. As a result, IoT collaboration can be done by integrating IoT components into web-based learning components using moodle. Moodle is highly suitable for a web-based learning medium with a wide range of facilities, including being able to collaborate with IoT. This design will be actualized by creating a web-based learning system that is collaborated with IoT devices, ranging from the prestige of students using smartcards (RFID), learning spaces that adopt smart classrooms, and also virtual learning that exists in one IoT collaboration package with e-learning.

That results are supported by the study of [6] which concluded that the effectiveness of teaching materials was determined based on the results of post-test mathematics literacy that shows the percentage of completed learning results of students is reached 82.76%. This shows that the teaching materials developed are effectively used to facilitate the achievement of students' mathematical literacy; [7] concluded that PAI learning evaluation results are good because the final results obtained by students from the field reality are above the minimum graduation limit of 65%.

The research of [5] aims to, (1) find a packaged learning for Audio-Video skill in vocational high school, (2) produce a Blended Learning Audio Video (BLAVO) model that meets valid criteria in vocational high school (3) resulting in a Blended Learning Audio Video (BLAVO) model that meets practical criteria in vocational high school, (4) resulting in a Blended Learning Audio Video (BLAVO) model that meets the effective criteria in vocational high school.

Prosser is well known for his principles in vocational education. That principles are 1). Vocational education will be efficient if the environment in which the student is trained is a replica of which they will work later, 2). Effective vocational education can only be provided where training tasks are performed in the same way, tools and machines as set out in the workplace, 3) Vocational education will be effective if training a person in the habit of thinking and working as necessary in the job itself, 4). Vocational education will be effective if it can enable each individual to share his interests, his knowledge, and his skills at the highest level, 5). Effective vocational education for any profession, position, or job can only be given to someone who needs it, who wants it, and who benefits from it.

The research that will be conducted refers to the 6th principle. Vocational Education will be effective if the experience of exercise to formwork habits and correct thinking habits are repeated, so it is suitable for the necessary in later work, 7). Vocational education will be effective if the teacher has more experience in applying skills and knowledge to the operations and work processes that will be carried out. 8). In each position, there is a minimum ability that a person must have to continue their work in that position. 9). Vocational education should pay attention to market demand. 10). An effective habitual coaching process in students will be achieved if training is given to a real job (value-laden experience). 11). A reliable source for knowing the content of training in a particular occupation is from the experience of the occupational experts. 12). Each work has a different body of content characteristics from one another, 13). Vocational education will be an efficient social service if it suits the necessities of someone who does need and done through vocational teaching, 14). Vocational education will be

efficient if the teaching methods are used to take into the characteristics of these learners, 15). Vocational education administration will be efficient if flexible, 16). Vocational education requires a certain cost and if it is not reached then vocational education should not be forced to operate.

4. Conclusion

Based on the results of the student response, the practical feasibility of Remote Lab IoT reached 84.58 % while the effectiveness was 91.29 %. A general statement or comment from the student says that "It is highly innovative and a solution of practicum courses during the pandemic, this application is very good and very helpful for participants in practicum online". It means that the student response from The Digital Electronics IoT Remote Lab is in the "excellent" category and "feasible" to be used in the learning process. The feasibility of Digital Electronics IoT Remote Lab reached 94.44%, the design experts commence that Digital Electronics IoT Remote Lab is in the category of "excellent" in this case "feasible" to be used as teaching material in digital electronics courses.

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